UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2009/2010

November 2009

EBP 202/3 - Polymer Structure
[Struktur Polimer]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains NINE printed pages before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEMBILAN muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

This paper consists of SEVEN questions.
[Kertas soalan ini mengandungi TUJUH soalan.

Instruction: Answer **FIVE** questions. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **LIMA** soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

The answers to all questions must start on a new page.
[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

1. [a] A linear polyethylene has a weight average molecular weight of 10.08×10^5 and polydispersity index of 1.2. Given that the bond length of C-C and bond angle is 0.154nm and 109.5^o respectively. The bond rotation is 60^o. Calculate the following:

(i) contour length
(ii) end-to-end distance (in the extended state)
(iii) RMS end-to-end distance according to freely jointed chain model

Satu polietilena linear mempunyai berat molekul purat berat 10.08×10^5 dan indeks polidispersiti bernilai 1.2. Diberikan panjang ikatan C-C dan sudut ikatan ialah 0.154 nm dan 109.5^o masing-masing. Sudut putaran ikatan ialah 60^o. Hitungkan:

(i) panjang kontur
(ii) jarak hujung-ke-hujung dalam keadaan diperpanjang
(iii) punca purata kuasa jarak hujung-ke-hujung berdasarkan model rantai bersambung bebas

(60 marks/*markah*)

[b] Write short note on the following subjects:

(i) reptation model
(ii) valence angle model

Tuliskan nota ringkas bagi perkara berikut:

(i) model reptasi
(ii) model sudut valensi

(40 marks/*markah*)

2. [a] Polybutadiene has a glass transition temperature of -92^{o}C, and polystyrene homopolymer has a glass transition temperature of +105^{o}C. Estimate the T_g of a 70/30 w/w poly(styrene-stat-butadiene) copolymer.

Polibutadiena mempunyai suhu peralihan kaca bernilai -92^{o}C, dan homopolimer polistirena mempunyai suhu peralihan kaca bernilai +105^{o}C. Anggarkan T_g bagi 70/30 w/w kopolimer poli(stirena-stat-butadiena).

(60 marks/*markah*)

[b] Write short note on the following subjects:

(i) glass transition temperature
(ii) free volume theory

Tuliskan nota ringkas bagi perkara berikut:

(i) suhu peralihan kaca
(ii) teori isipadu bebas

(40 marks/*markah*)

3. [a] "Polymers of dienes have potential for head-to-head and head-to-tail isomerism and variations in double-bond position". Comment on this statement based on TWO suitable diene polymers.

"Polimer diena mempunyai keupayaan untuk menunjukkan isomerisme kepala-ke-kepala dan kepala-ke-ekor, serta variasi dalam kedudukan ikatan dubel." Komen kenyataan ini berdasarkan DUA jenis polimer diena yang sesuai.

(40 marks/*markah*)

[b] A linear amorphous polymer has a T_g of +15°C. At 25°C, it has a melt viscosity of 4 x 10^8 poises. What is the difference between its melt viscosity at 50°C and 60°C?

Satu polimer amorfus linear mempunyai T_g +15°C. Pada suhu 25°C, polimer tersebut mempunyai kelikatan leburan sebanyak 4 x 10^8 poises. Apakah perbezaan kelikatan leburan bagi polimer itu antara suhu 50°C dan 60°C?

(60 marks/*markah*)

4. [a] You are given a task to measure density of a polymer sample using a pycnometer bottle. Explain the basic principle of your measurement and also describe in detail the methodology of your experiment.

Anda diberikan satu tugasan untuk mengukur ketumpatan suatu sampel polimer menggunakan botol piknometer. Terangkan prinsip asas kaedah pengukuran anda dan jelaskan secara terperinci kaedah eksperimen anda

(40 marks/*markah*)

[b] Two polyetheylene samples were produced using two different processing techniques. One was prepared using compression moulding and the other was moulded using an injection molder. The following are their respective densities:

Compression moulded	→	ρ_{comp} = 0.90 g/cm^3
Injection moulded	→	ρ_{inj} = 0.96 g/cm^3

Given;

- Polyethylene form an orthorombic crystal having the following unit cell dimension:

  a = 0.742 nm
  b = 0.494 nm
  c = 0.255 nm

- Specific volume for an amorphous polyethylene, ν_a, is 1.18 x 10^{-3} m^3/kg

- Relative atomic mass of hydrogen and carbon are:

  H = 1 C =12

- No. of repeat unit per unit cell = 2

- Avogadro number, N_A, = 6.023 x 10^{23} mol^{-1}

Using the above given information, determine the degree of crystallinity for both samples.

Dua sampel polietilena dihasilkan menggunakan dua teknik pemprosesan yang berbeza. Satu daripada sampel tersebut telah disediakan menggunakan pengacuanan mampatan dan satu lagi diacuankan menggunakan pengacuanan suntikan. Berikut adalah ketumpatan bagi setiap sampel:

Pengacuanan mampatan → $\rho_{comp} = 0.90\ g/cm^3$

Pengacuanan suntikan → $\rho_{inj} = 0.96\ g/cm^3$

Diberi,

- *Polietilena membentuk hablur ortorombik yang mempunyai dimensi sel unit seperti berikut:*

  $a = 0.742\ nm$

  $b = 0.494\ nm$

  $c = 0.255\ nm$

- *Isipadu spesifik bagi polietilena yang amorfus, v_a, is $1.18 \times 10^{-3}\ m^3/kg$*

- *Jisim atom relatif bagi hidrogen dan karbon ialah:*

  $H = 1$ $C = 12$

- *Bilangan unit ulangan per sel unit = 2*

- *Nombor Avogadro, N_A, = $6.023 \times 10^{23}\ mol^{-1}$*

Menggunakan maklumat yang diberikan di atas, tentukan darjah keterhabluran kedua-dua sampel tersebut.

(60 marks/*markah*)

5. [a] In describing mechanisms of organised macromolecules packing in a small molecular space such as found in polymer single crystals, chain folding models have been proposed. Elaborate the features of these models with the assistance of suitable diagrams.

Bagi menerangkan mekanisme penyusunan rapi makromolekul dalam ruangan molekul yang kecil seperti yang ditemui dalam hablur tunggal polimer, model-model Lipatan Rantai telah dicadangkan. Huraikan ciri-ciri model-model tersebut dengan bantuan rajah yang sesuai.

(60 marks/*markah*)

[b] Polymer single crystals are polymer crystals that are derived from solution. What do you called polymer crystals that are derived from polymer melts? Describes the similarity and difference of both polymer crystals.

Hablur tunggal polimer ialah hablur polimer yang diterbitkan daripada larutan. Apakah nama yang anda berikan kepada hablur polimer yang diterbitkan daripada leburan polimer? Jelaskan persamaan dan perbezaan kedua-dua hablur tersebut.

(40 marks/*markah*)

6. [a] Show that for three dimensional spherulite growth, equation of crystallisation kinetics can be expressed as:

$$\frac{W_L}{W_o} = 1 - \frac{\pi}{3}\left(\frac{\rho_s}{\rho_L}\right) N G^3 t^4$$

Clearly state assumptions that are made and what is the significance of the value 4 in the t^4 term.

Tunjukkan bahawa bagi pertumbuhan tiga dimensi sferulit, persamaan kinetik penghabluran boleh diungkapkan sebagai:

$$\frac{W_L}{W_o} = 1 - \frac{\pi}{3}\left(\frac{\rho_s}{\rho_L}\right) N G^3 t^4$$

Nyatakan dengan jelas anggapan-anggapan yang dibuat dan kepentingan nilai 4 pada ungkapan t^4.

(70 marks/*markah*)

[b] Explain how molecular orientation that occured during polymer processing can affect degree of crystallinity.

Terangkan bagaimana orientasi molekul yang berlaku semasa pemprosesan polimer boleh mempengaruhi darjah keterhabluran.

(30 marks/*markah*)

7. [a] Poly(vinyl chloride) has glass transition temperature of 65°C. Proposed THREE alternatives to increase the T_g of poly(vinyl chloride) to 80°C.

Poli(vinil klorida) mempunyai suhu peralihan kaca bernilai 65°C. Cadangkan TIGA cara untuk meningkatkan T_g bagi poli(vinil klorida) ke 80°C.

(30 marks/*markah*)

[b] Give the difference between the term configuration and conformation.

Berikan perbezaan antara istilah konfigurasi dan konformasi.

(20 marks/*markah*)

[c] When Differential Scanning Calorimetry (DSC) tests were conducted on two samples of polyethylene terephthalate (PET), these results were obtained. PET virgin sample (pellet) weighing 13.400 mg gave a melting enthalpy, ΔH_m of 0.3385 Joule whereas another PET sample (weighing 12.400 mg), which has gone through an injection moulding process recorded a melting enthalpy, ΔH_m of 0.3895 Joule.

With the knowledge of melting enthalpy of a 100% PET crystal, ΔH^o_m is 106 Joule/g, calculate the degree of crystallinity of both PET samples. Why there is a difference of melting enthalpy between these samples?

Apabila suatu ujian Kalorimetri Penskanan Pembezaan dijalankan ke atas dua sampel polietilena tereftalat (PET), keputusan berikut diperolehi. Sampel asal (pelet) PET seberat 13.400 mg memberikan entalpi peleburan, ΔH_m = 0.3385 Joule manakala sampel PET yang telah mengalami proses pengacuanan suntikan (seberat 12.400 mg) merekodkan entalpi peleburan ΔH_m = 0.3895 Joule.

Berbantukan maklumat entalpi peleburan untuk 100% hablur PET, (ΔH^o_m = 106 Joule/g), kirakan darjah keterhabluran bagi kedua-dua sampel PET tersebut. Mengapakah terdapat perbezaan entalpi peleburan di sampel-sampel PET itu.

(50 marks/*markah*)

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